

Effect of Fat and CHO Meals on Intermittent Exercise in Soccer Players

Authors

A. T. Hulton¹, J. P. Edwards², W. Gregson¹, D. MacLaren¹, D. A. Doran¹

Affiliations

¹ Research Institute for Sport & Exercise Sciences, Liverpool John Moores University, Liverpool, United Kingdom

² School of Sport, Health and Exercise Sciences, Bangor University, Bangor, United Kingdom

Key words

- high fat meals
- pre-exercise meals
- intermittent exercise
- association football

Abstract

Pre-exercise meals containing carbohydrates (CHO) are recommended to athletes, although there is evidence to suggest that a high fat meal prior to exercise increases utilisation of fats yet may not adversely affect performance. This study investigated the effect of a high fat and high CHO pre-exercise meal prior to high intensity intermittent exercise. Ten male recreational soccer players performed a soccer specific protocol followed by a 1 km time trial 3 ½ h after ingesting one of 2 test meals, high fat meal (HFM) or a high CHO meal (HCM). Blood glucose, fatty acids (FA), glycerol, β -hydroxybutyrate, lactate and insulin were assessed prior to the meal, pre-exercise, half-

time, and post-exercise, whilst rates of CHO and fat oxidation were determined at 4 time points during the exercise as well as heart rate (HR) and rating of perceived exertion (RPE). Significant increases in FA, glycerol, β -hydroxybutyrate and fat oxidation after the HFM were observed, while CHO oxidation was significantly higher following the HCM ($P < 0.05$). No performance effect was found for the 1 km time trial (HFM: 228.6 \pm 14.4 s; HCM: 229.4 \pm 26.5 s) (mean \pm SD). These findings suggest that the type of meal ingested prior to soccer simulated exercise has an impact on metabolism, but not on the subsequent performance as determined in the present study.

Introduction

The need to maintain glycogen stores during soccer has been previously illustrated [1] as performance can be severely affected as muscle glycogen levels are depleted. Similarly previous research [25] found a significant reduction in muscle glycogen after 90 min of match play, and observed that distance covered was reduced for players expressing lower levels of muscle glycogen compared to those with higher levels. More recently, authors [15] investigated muscle glycogen levels pre and post match, and observed a decrease (449 ± 23 – 255 ± 22 mmol \cdot kg⁻¹ d.w.) in overall muscle glycogen levels and found that 47% of the muscle fibres were completely or almost empty of glycogen after the match. It is clear that muscle glycogen levels are reduced playing soccer, and that this may impact on the high intensity work during the game, especially the latter stages of matches.

In order to optimise muscle glycogen levels, the provision of diets with high carbohydrate (CHO) content is advocated. It has been observed [3]

that greater running distances during an intermittent running test to exhaustion were found following a 48 h high CHO diet relative to a normal diet. Similarly [2] a high CHO diet prior to small sided soccer games resulted in the players completing a significantly greater amount of high intensity activity. In addition to maintaining a diet high in carbohydrate, several studies have argued that pre-exercise meals favourably impact upon endurance performance [20,26]. Moreover, prolonged intermittent exercise performance may also benefit from the ingestion of pre-performance meals high in CHO. Researchers [16,17] have prescribed a single pre-exercise meal prior to a soccer specific intermittent exercise protocol and found that both high and low glycaemic index CHO meals improved repeated sprint performance compared to a fasting state.

Following a high CHO meal (HCM) Chrysanthopoulos et al. [7] has suggested a potential 10% increase in muscle glycogen. Relatively few studies have investigated the effect of a single high fat meal (HFM) compared to a single HCM [21,22,28]. Whilst, their findings have indicated

accepted after revision
June 16, 2012

Bibliography

DOI <http://dx.doi.org/10.1055/s-0032-1321798>
Published online:
September 12, 2012
Int J Sports Med 2013; 34:
165–169 © Georg Thieme
Verlag KG Stuttgart · New York
ISSN 0172-4622

Correspondence

Andrew Thomas Hulton

Sport & Exercise Sciences
Liverpool John Moores
University
Tom Reilly Building
L3 3AF Liverpool
United Kingdom
Tel.: +44/151/231 4358
Fax: +44/151/231 4353
a.t.hulton@ljmu.ac.uk

Food	Amount	Carbohydrate (g)	Protein (g)	Fat (g)	Energy (kcal)
High Fat					
milkshake	200ml	22.0	8.4	7.0	179.1
double cream	50ml	1.2	1.1	37.9	349.9
egg fried rice	75g	11.4	1.6	1.7	64.9
chicken breast	75g	0.3	19.6	4.4	118.3
korma sauce	200g	24.6	4.6	19.2	283.5
total	–	59.4	35.3	70.2	995.6
High CHO					
apple juice	590ml	65.5	0.6	0	248.0
basmati rice	100g	71.1	9.7	1.3	317.1
chicken breast	100g	0.3	26.1	5.8	157.7
tomato based sauce	300g	23.1	5.1	17.1	260.9
total	–	160.0	41.5	24.2	983.7

Table 1 Meal details for the HFM and HCM.

no improvements in performance for a cycling capacity test [21,22] or for time trial performance [28], critically these studies demonstrate no performance decrements. Underlying these observations is the principle that a HFM enables an increase in fatty acids (FA) availability during the postprandial period and onset of exercise, an increase in the rate of fat oxidation resulting in a matched or enhanced performance.

The purpose of the present study was to investigate the metabolic and performance effects following consumption of a HFM and HCM prior to high intensity intermittent exercise. This approach to nutritional preparation prior to a simulated soccer protocol has not been investigated before, which adds to the novelty of the current study. Both meal design and timing of consumption were intended to convey a realistic scenario commonly observed in professional soccer. We hypothesised that the HFM would promote fat availability and oxidation, and maintain 1 km time trial performance after 90 min of high intensity intermittent exercise.

Method



Participants

Ten male recreational soccer players all of whom trained twice a week and played a weekly competitive match were recruited for the study (Age: 24.3 ± 2.3 yrs [range: 21–26 yrs]; Body height: 176 ± 6 cm [range: 1.60–1.85 cm]; Body mass: 74.2 ± 9.8 kg [range: 57.95–85.75 kg]). Participants provided written informed consent and the study was approved by the Liverpool John Moores University Ethics Committee. Furthermore, the study was performed in accordance with the ethical standards of the International Journal of Sports Medicine [13].

Experimental design

Each participant was required to attend the laboratory a minimum of 4 occasions (environmental laboratory conditions did not differ between trials, with average temperature and humidity set at 19.7°C and 28.9%). The first 2 were for familiarisation of the intermittent treadmill protocol, in which participants completed 15 min of the intermittent treadmill protocol, and then undertook a 1 km time trial. If the completion time for the time trial was greater than 2%, additional laboratory visits were replicated in the same fashion as described above, until test-retest times were within 2%. Only 1 of the participants had to attend the laboratory for a third visit due to his test retest results being $>2\%$. The final 2 visits were to complete the experimental

condition, which were conducted in a counterbalanced manner separated by 7 days.

Test meals

Test meals (● **Table 1**) varied in macronutrient content although the total energy intake was similar (HFM – 995 kcal; HCM – 984 kcal). The macronutrient content for the HFM was CHO: 22%, protein: 14%, fat: 64%, and for the HCM (Estimation of Glycaemic Index=41 [9]) the macronutrient content was CHO: 61%, protein: 17%, fat: 22%. Replicating common practise within soccer, participants consumed the same standardised breakfast of cereal and fruit juice (total energy=377 kcal; CHO=79g; Fat=3g; Protein=13g) on both test days at 8 a.m., with participants also abstaining from alcohol and any strenuous exercise for 48h prior to the test. The diet 24h prior to the test was also kept constant for both trials. Participants consumed on average 346.8g CHO with a total calorie intake of 2303.6 kcal, which represents 60% energy coming from CHO.

Protocol

Following collection of the first venous blood sample (20 mL) at approximately 11.10 a.m., participants consumed the test meal at 11.30 a.m. (i.e. 3½ hours before the start of exercise and replicates the current practise of professional soccer players for a 15.00 p.m. kick off). Blood samples were collected from finger prick samples pre-meal, and at 5, 30, 60, 90 and 120 min post meal for the determination of glucose (Glucose Hemocue 201+, Hemocue, Ängelholm, Sweden). During the postprandial period, participants drank 1 L of water and rested until they returned to the laboratory at 14.30 p.m. for the pre-exercise blood sample.

A standardised warm up consisting of light jogging and static stretching was instigated prior to the start of the protocol at 15.00 p.m. The soccer specific protocol [8] was completed on a motorised treadmill (H/P Cosmos Pulsar, Nussdorf-Traunstein, Germany). This protocol has been used in a previous study investigating pre-exercise meals for intermittent high intensity exercise [14]. The protocol imitates the activity patterns that occur in soccer matches and includes bouts of walking (31–39 s), jogging (41–46 s), cruising (41–45 s), sprinting (16–21 s) and standing stationary. The proportion of each individual activity is similar to those obtained from motion analysis [24] and comprises of 2 22 min 30 s blocks to comprise one half of 45 min; a total of 4 blocks with a 15 min half time constituted the whole trial.

During the first 45 min, capillary blood samples were collected and analysed for blood glucose after 10, 20, and 30 min in order to ascertain if rebound hypoglycaemia was evident in the early stages of exercise. A 15 min half time break was provided during

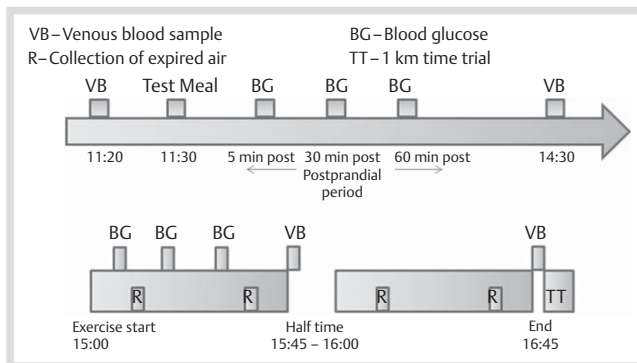


Fig. 1 Schematic of the entire protocol.

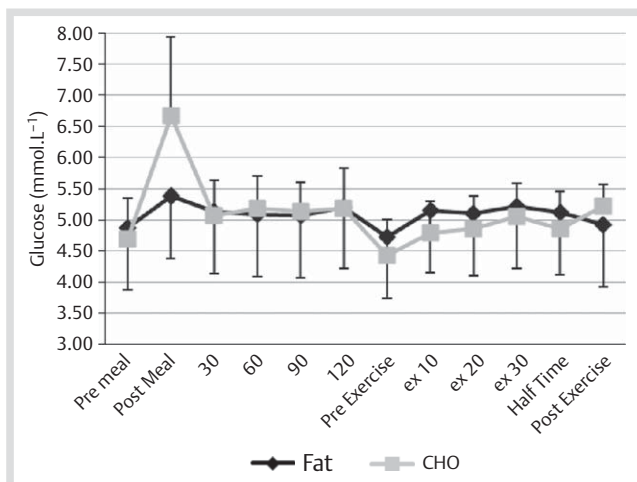


Fig. 2 Blood glucose concentration prior to the test meal, throughout the postprandial period and exercise.

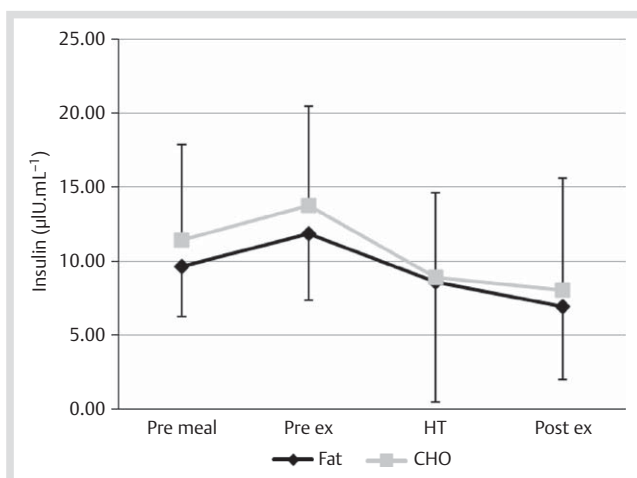


Fig. 3 Insulin concentration prior to the test meal and throughout exercise.

which subjects drank 5 mL·kg⁻¹ of water and a further venous blood sample was collected. The second 45 min was a replication of activity patterns experienced during the first 45 min, totalling 90 min before a final venous blood sample was collected immediately post-exercise and before participants ran the 1 km time trial. Venous blood samples were collected from the antecubital vein pre-meal, before exercise, at half time, and after exercise, and analysed for fatty acid (FA), glycerol, β -hydroxybutyrate and lac-

tic acid using enzymatic spectrophotometric assays on a RX Daytona clinical chemistry analyser (Randox, Co. Antrim, UK). Serum samples were also analysed for insulin using an Immulite 1000 immunoassay analyser (Siemens Healthcare Diagnostics, Illinois, USA).

At 4 time points during the protocol (10, 35, 55, and 80 min) expired gas was collected for 90 s using Douglas Bags (Cranlea, Birmingham, UK) and analysed with a Servomex 1 440 Gas Analyser (Servomex, Crowborough, UK), from which calculations of fat and CHO oxidation were made [10].

Subjective measurements of rating of perceived exertion [6] were recorded every 5 min. Heart rate was continually measured and averaged over 5 min periods using a Polar S610 (Polar, Kempele, Finland). A schematic of the protocol can be seen in **Fig. 1**. The performance test was a 1 km time trial that was self paced during which participants were blinded to the time and speeds displayed on the treadmill. A performance test rather than a test for exercise capacity (i.e., time to fatigue) was deemed more appropriate and represented a consideration of 'what was left in the fuel tank'. Furthermore, such a high intensity task would necessitate use of all muscle fibres, although the type IIx fibres would be significantly employed [12].

Statistics

SPSS software (version 17 SPSS, Chicago, IL) was used for data entry and analysis. Analysis of variance for repeated measures on 2 factors (experimental condition and time) was used to analyse differences in the physiologic and metabolic responses in both trials. If a significant interaction was obtained, a least significance difference post hoc test (Bonferroni) was used to determine the location of the variance [5]. A paired t-test was used to analyse time trial performance times. Differences were considered significant at $P < 0.05$. All data are presented as the mean \pm SD.

Results

There were no differences between HCM and HFM for blood glucose, insulin and lactate concentrations (**Fig. 2, 3, 5**), only a significant effect for time ($p < 0.05$) for blood glucose was apparent. It must be noted that when the area under the insulin-time curve is measured (HCM: $25.6 \pm 13.7 \mu\text{U}\cdot\text{mL}$; HFM: $20.9 \pm 11.1 \mu\text{U}\cdot\text{mL}$), although not significant ($p = 0.059$), it does suggest a tendency that may be of physiological importance.

Significantly higher plasma glycerol and FA concentrations (**Fig. 4**) were observed after the HFM than the HCM ($p < 0.001$) and likewise for β -hydroxybutyrate ($p < 0.05$) (**Fig. 5**). All metabolites increased over time ($p < 0.05$), and significant interactions observed for plasma glycerol and FA ($p < 0.005$). The rate of fat oxidation was also significantly greater after the HFM than the HCM ($p < 0.05$), whereas CHO oxidation was significantly higher after the HCM than the HFM ($p < 0.05$) (**Fig. 6**). Fat oxidation was also observed to increase over time ($p < 0.05$) and was approaching significance for an interaction effect ($p = 0.055$).

Performance completion times were 229.4 ± 26.5 s and 228.8 ± 14.4 s following HCM and HFM respectively, indicating similarities between conditions. Individual analysis observed that 5 participants were faster after HCM and 5 were faster after HFM. In addition, there was no significant effect on performance when data was analysed by test order (Test 1: 226.2 ± 14 s; Test 2: 231.8 ± 26.4 s).

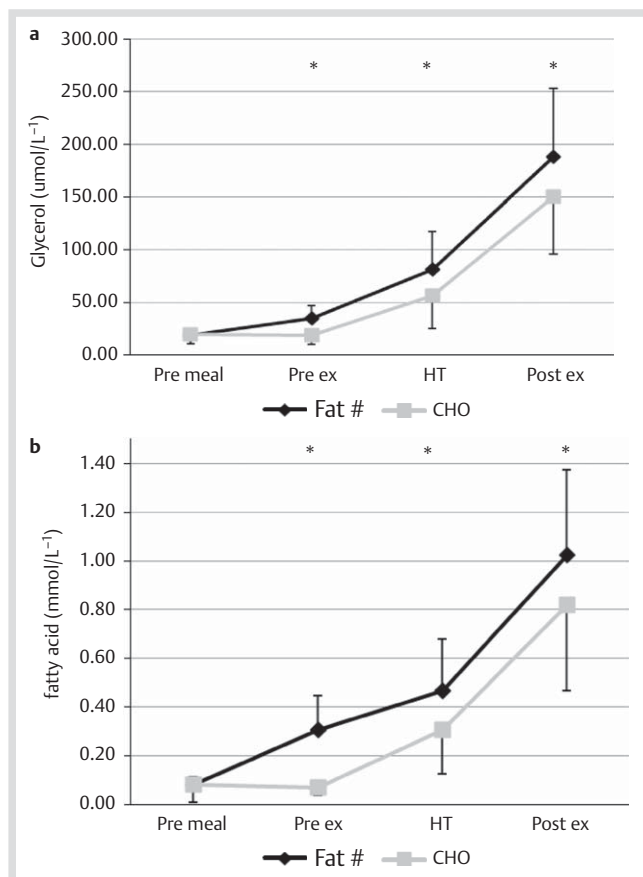


Fig. 4 **a** Glycerol and **b** FA concentration prior to the test meal and throughout exercise. # Indicate a significant main effect. * Indicate where a significant interaction has occurred between time points (Bonferroni corrected paired t-test).

HR and RPE both increased throughout the protocol ($P < 0.001$), with no difference between conditions (HR-HFM: 145 ± 5.93 , HCM: 146 ± 7.71 ; RPE-HFM: 13.0 ± 1.13 , HCM: 13.5 ± 1.34) ($P > 0.05$).

Discussion

The main finding from this investigation was increased fat oxidation and fat metabolites following the ingestion of a HFM, resulting in similar performance for the 1-km run following the intermittent high intensity exercise. Fat oxidation following consumption of the HFM was $28 \pm 7.71\%$ greater than that observed following the HCM. Conversely, CHO oxidation was $35 \pm 6.36\%$ greater following the HCM compared to the HFM. Previous research [16] observed greater fat oxidation with the fasted control compared to high and low glycaemic meals during a simulated soccer protocol. However, present data indicates an exaggerated increase in fat oxidation with the consumption of a HFM. Furthermore, fat metabolite responses are in accordance with previous research; with significant increases in FA [21,22,28], glycerol [21,22] and β -hydroxybutyrate [21] after the ingestion of a HFM and during subsequent exercise performance. The observations of FA are consistent with others who report increases over the 90 min of match play, irrespective of the pre-exercise nutritional strategies employed [15]. Meals that are high in CHO suppress plasma FA concentrations [28], which may be the case since the HFM contained 59.4g of CHO compared to 160g with the HCM. Elevated glycerol concentrations following the HFM were

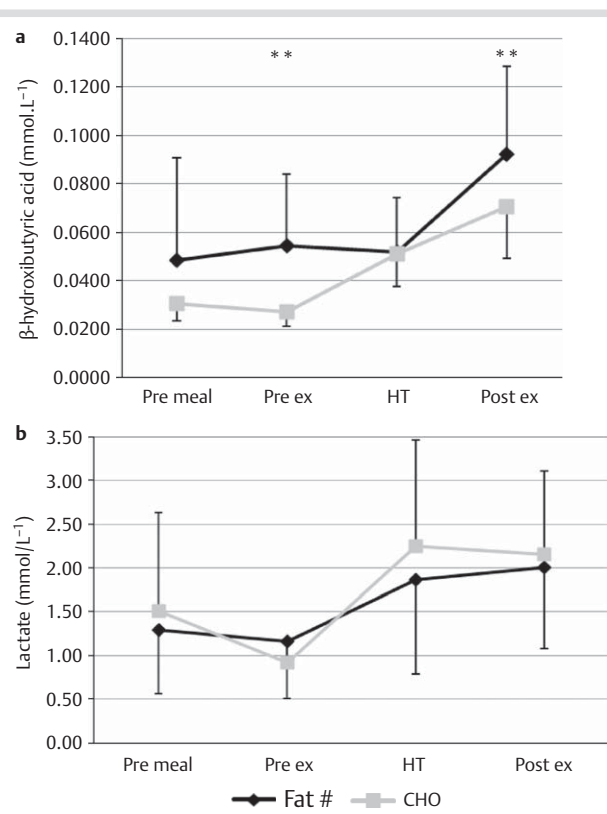


Fig. 5 **a** β -hydroxybutyrate and **b** Lactate concentration prior to the test meal and throughout exercise. # Indicate a significant main effect. ** Significant time effect between Pre ex and Post ex.

observed in the current study and are in agreement with others [28]. This finding may be indicative of an enhanced rate of lipolysis. An increase in β -hydroxybutyrate concentration was also found throughout exercise following ingestion of the HFM, which may reflect stimulation of hepatic ketosis due to greater levels of fat metabolism. This result reflects similar observations in cycling [21]. The presence of elevated concentrations of fat metabolites following the consumption of a HFM relative to the HCM may be attributed to the greater availability of fat following the HFM. However, it may also be a consequence of an elevated insulin concentration preceding the HCM, as insulin is a known antilipolytic hormone that may suppress lipolysis. Notionally, the consumption of a HCM should mediate insulin release and a subsequent inhibition of lipolysis [17]. Whilst no significant effect for insulin concentration was noted between protocols, analysis of the area under the insulin-time curve may suggest a tendency towards a physiological difference favouring the HCM. A limiting factor within the current investigation was the absence of insulin measures during the postprandial period. Montain et al. [19] showed that despite similar postprandial insulin concentrations 4 h prior to exercise compared to 12 h postprandially there was a difference in CHO oxidation and fat metabolites between conditions, supporting a long lasting effect of insulin. Consistent with the current investigation Whitley et al. [28] reported no significant differences in insulin concentrations following the consumption of either a HFM or HCM during exercise. However, again insulin was not analysed postprandially so similar caveats to the present investigations may be warranted. This contrasts the observations from previous research [21] that noted significant elevations in insulin concentrations after a HCM relative to

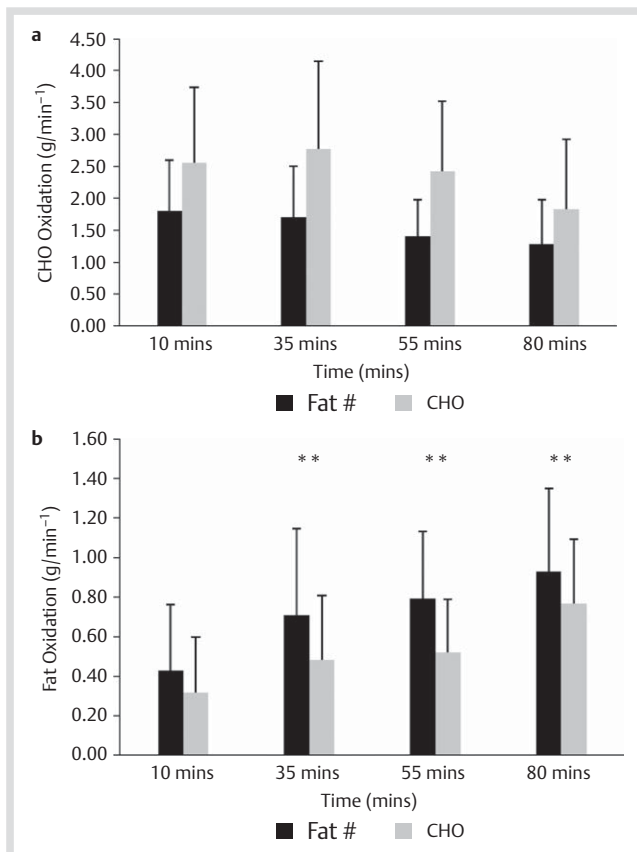


Fig. 6 a CHO oxidation and b Fat oxidation measure during exercise. # Indicate a significant main effect. ** Significant time effect between 35 min, 55 min and 80 min.

a HFM. This divergence in insulin responses between the present study and others [21] could be attributed to the volumes and types of CHO ingested.

Even though significant findings were observed in favour of an increase in fat oxidation and fat metabolites, the current investigation found no difference in the 1 km time trial performance test following the intermittent high intensity exercise with either test meal (HCM: 229.4 ± 26.5 s; HFM: 228.8 ± 14.4 s). This performance result was in agreement with previous studies [21,22,28], although other investigations have shown reductions in performance for short term high fat diets that last between 1 day [27], 3 days [4,18,23] or 4 days [11]. A possible explanation for the performance impairments with these studies is the high fat diets they utilise may result in a reduction in muscle and liver glycogen stores prior to exercise. This is unlikely to have occurred in the present study as the participants consumed a normal diet in the 24 h period leading up to the investigation, which on average consisted of 346.8 g of CHO, and the same high CHO breakfast was also consumed on the morning of the test day. The observations that the HFM did not impair performance may be attributable to the additional CHO intake (79 g) consumed within the standardised breakfast in addition to the likelihood of an adequate carbohydrate intake in the 24-h prior to the trial (~350 g).

In conclusion, following a standardised breakfast and an adequate carbohydrate intake over a previous 24-h period, ingestion of pre-exercise meals with a high fat or high carbohydrate content produce a similar performance during a 1 km time trial after a 90-min simulated soccer protocol on the treadmill despite variations in

CHO and fat oxidation. Under these conditions soccer players may have a broader choice of foods than usually recommended.

References

- Agnevik G. Football: Sport Physiology Report Number 7 [in Swedish]. Stockholm: Trygg-Hansa, 1970
- Balsom PD, Wood K, Olsson P, Ekblom B. Carbohydrate intake and multiple sprint sports: with special reference to football (soccer). *Int J Sports Med* 1999; 20: 48–52
- Bangsbo J, Nørregaard L, Thorsøe F. The effect of carbohydrate diet on intermittent exercise performance. *Int J Sports Med* 1992; 13: 152–157
- Bergström J, Hermansen L, Hultman E, Saltin B. Diet, muscle glycogen and physical performance. *Acta Physiol Scand* 1967; 71: 140–150
- Bland JM, Altman DG. Multiple significance tests: the Bonferroni method. *BMJ* 1995; 310: 170
- Borg G. Perceived exertion as an indicator of somatic stress. *Scand J Rehabil Med* 1970; 2: 93–98
- Chryssanthopoulos C, Williams C, Nowitz A, Bogdanis G. Skeletal muscle glycogen concentration and metabolic responses following a high glycaemic carbohydrate breakfast. *J Sports Sci* 2004; 22: 1065–1071
- Drust B, Reilly T, Cable NT. Physiological responses to laboratory-based soccer-specific intermittent and continuous exercise. *J Sports Sci* 2000; 18: 885–892
- Foster-Powell K, Holt SH, Brand-Miller JC. International table of glycemic index and glycemic load values. *Am J Clin Nutr* 2002; 76: 5–56
- Frayn KN. Calculation of substrate oxidation rates in vivo from gaseous exchanges. *J Appl Physiol* 1983; 55: 628–634
- Galbo H, Holst JJ, Christensen NJ. The effect of different diets and of insulin on the hormonal response to prolonged exercise. *Acta Physiol Scand* 1979; 10: 19–32
- Greenhaff PL, Nevill ME, Soderlund K, Bodin K, Boobis LH, Williams C, Hultman E. The metabolic responses of human type I and II muscle fibres during maximal treadmill sprinting. *J Physiol* 1994; 1: 149–155
- Harriss DJ, Atkinson G. Update – ethical standards in sport and exercise science research. *Int J Sports Med* 2011; 32: 819–821
- Hulton AT, Gregson W, MacLaren DPM, Doran DP. Effects of GI meals on intermittent exercise. *Int J Sports Med* 2012; 33: 459–462
- Krustrup P, Mohr M, Steensberg A, Bencke J, Kiaer M, Bangsbo J. Muscle and blood metabolites during a soccer game: implications for sprint performance. *Med Sci Sports Exerc* 2006; 38: 1–10
- Little JP, Chilibeck PD, Ciona D, Vandenberg A, Zello GA. The effects of low- and high-glycemic index foods on high intermittent exercise. *Int J Sport Physiol Perform* 2009; 4: 367–380
- Little JP, Chilibeck PD, Ciona D, Forbes S, Rees H, Vandenberg A, Zello GA. Effect of low- and high-glycemic-index meals on metabolism and performance during high intermittent exercise. *Int J Sports Nutr Exerc Metab* 2010; 20: 447–456
- Martin B, Robinson S, Robertshaw D. Influence of diet on leg uptake of glucose during heavy exercise. *Am J Clin Nutr* 1978; 31: 62–67
- Mountain SJ, Hopper MK, Coggan AR, Coyle EF. Exercise metabolism at different time intervals after a meal. *J Appl Physiol* 1991; 70: 882–888
- Neufer PD, Costill DL, Flynn MG, Kirwan JP, Mitchell JB, Houmard J. Improvements in exercise performance: effects of carbohydrate feedings and diet. *J Appl Physiol* 1987; 62: 983–988
- Okano G, Sato Y, Takumi Y, Sugawara M. Effect of 4 h preexercise high carbohydrate and high fat meal ingestion on endurance performance and metabolism. *Int J Sports Med* 1996; 17: 530–534
- Okano G, Sato Y, Murata Y. Effect of elevated blood FFA levels on endurance performance after a single fat meal ingestion. *Med Sci Sports Exerc* 1998; 30: 763–768
- Pitsiladis YP, Maughan RJ. The effects of exercise and diet manipulation on the capacity to perform prolonged exercise in the heat and in the cold in trained humans. *J Physiol* 1999; 517: 919–930
- Reilly T, Thomas V. A motion analysis of work-rate in different positional roles in professional soccer match play. *J Hum Mov Stud* 1976; 7: 87–97
- Saltin B. Metabolic fundamentals in exercise. *Med Sci Sports Exerc* 1973; 5: 137–146
- Sherman WM, Brodowicz G, Wright DA, Allen WK, Simonsen J, Dernbach A. Effects of 4 h preexercise carbohydrate feedings on cycling performance. *Med Sci Sports Exerc* 1989; 21: 598–604
- Starling RD, Trappe TA, Parcell A, Kerr CG, Fink WJ, Costill DL. Effects of diet on muscle triglyceride and endurance performance. *J Appl Physiol* 1997; 82: 1185–1189
- Whitley HA, Humphreys SM, Campbell IT, Keegan MA, Jayanetti TD, Sperry DA, MacLaren DP, Reilly T, Frayn KN. Metabolic and performance responses during endurance exercise after high-fat and high-carbohydrate meals. *J Appl Physiol* 1998; 85: 418–424